

# Ryan Vaughn

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Curriculum Vitae

## Mailing Address

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## Education

- 2015-Present Ph.D. in Mathematics | George Mason University, Fairfax, Virginia  
Advisor: Dr. Tim Sauer and Dr. Tyrus Berry  
GPA: 3.89
- 2015-2018 MS in Mathematics (Applied Emphasis) | George Mason University
- 2009-2013 BS in Mathematics | University of Mary Washington,  
Fredericksburg, VA.

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## Research Interests

Manifold Learning | Diffusion Maps | Applied Differential Geometry and Topology | Mesh-Free Methods in PDE | Discrete and Finite Element Exterior Calculus | Numerical Analysis

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## Research Experience

- 2016-Present **Graduate Research Assistant**  
George Mason University (GMU), Fairfax, VA  
Advisor: Dr. Tim Sauer and Dr. Tyrus Berry

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## Preprints and Publications

- (1) R. Vaughn, H. Antil, and T. Berry *Diffusion Maps for Embedded Manifolds with Boundary with Applications to PDEs* In Preparation, 2019. Preprint available at: [math.gmu.edu/~rvaughn5/](http://math.gmu.edu/~rvaughn5/)  
*There has been recent interest in using Diffusion Maps as a mesh-free numerical scheme for solving PDEs on manifolds. We generalize the proof of convergence of Diffusion Maps near the boundary using semigeodesic coordinates, and obtain a uniform second-order asymptotic expansion. Despite the well-known pointwise blowup at the boundary, we prove that the Diffusion Maps graph Laplacian converges to the manifold Laplacian in the weak sense. Combined with a novel method of estimating boundary integrals, we can now numerically solve several boundary value problems on manifolds with boundary which were previously unattainable.*
- (2) O. Babb, A. Malhotra, T. Berry, Y. Ayoub, and R. Vaughn *Minimum Curvature Embeddings for Dimensionality Reduction*. In Preparation, 17 pages, 2019.  
*The leading term of bias error in Diffusion Maps is proportional to the second fundamental form of the embedded submanifold. We numerically implement a constrained geometric heat flow on data sampled from a manifold and show that in some cases, the flow reduces the second fundamental form of the embedding, therefore providing an algorithm to reduce dimensionality and obtain optimal embeddings in terms of minimal extrinsic curvature.*
- (3) K.Mellinger, R. Vaughn, and O. Vega (2013). Graphs Embedded into Finite Projective Planes. Contributions to Discrete Mathematics. Volume 10.

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## Presentations and Talks

- (*Future Invited Talk*) May 2020: **A Data-Driven Approach to Solving Boundary Value Problems with Diffusion Maps**. SIAM Conference on the Mathematics of Data Science, Cincinnati, OH.
- March 2019: Student Research Talks, George Mason University, Fairfax, VA. **The Hodge Decomposition Theorem**
- September 2018: Student Research Talks, George Mason University, Fairfax, VA. **Kernel Methods in Dimensionality Reduction**
- September 2016: Student Research Talks, George Mason University, Fairfax, VA. **What is Persistent Homology?**

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## Teaching Experience

- 2017-2018      **Seminar Organizer: Differential Geometry Learning Seminar**  
George Mason University (GMU), Fairfax, VA  
*Gave weekly lectures about differential topology. The seminar covered introduction to differential topology including differential forms, the exterior derivative, and De Rham cohomology.*
- 2015-2016      **Graduate Teaching Assistant**  
George Mason University  
*Taught Calculus 1 summer course, as well as recitation instruction for Calculus I and Honors Calculus III courses.*
- 2014-2015      **Assistant Center Director**  
Mathnasium of Tysons  
*Responsible for individualized instruction of  $K - 12$  students in a group tutoring environment. Specialized in advanced instruction as well as math competition and academic test prep.*
- 2014-2015      **Tutor and Summer School Curriculum Development**  
Academic Connections, LLC  
*Provided in-home tutoring for between 10-20 students. Developed a curriculum for a summer program for students in Algebra 1 and Geometry.*

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## Honors and Awards

- Spring 2013: Outstanding Poster Presentation Award, Joint Mathematics Meeting San Diego
- Fall 2012: Recipient of \$5000 travel grant in order to attend Budapest Semesters in Mathematics
- Summer 2012: Fresno State REU in Combinatorics of Finite Geometries
- Summer 2011: 2nd Place Presentation, *Homotopy Theory of Finite Topological Spaces*, UMW Summer Science Institute Fredericksburg, VA

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## Service and Outreach

- Graduate Student Mentor: Mason Experimental Geometry Lab Project, 2017-2018.
- Volunteer: Mason Experimental Geometry Lab Outreach, Spring 2017.
- Co-Organizer: Professional Development Conference for Association for Women in Mathematics, George Mason University, Spring 2017.